Nonpoint Source Pollution Control in the City of Austin

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INTRODUCTION

The City of Austin stretches from the Texas hill country of the Edwards Plateau, eastward to the deep soils of the Blackland Prairie. The unique environment which results from this rapid geologic and ecologic transition is further enhanced by the Colorado river flowing directly through the City. The Colorado provides an abundance of high quality water for the citizens and visitors of Austin.

Lake Travis, Lake Austin, and Town Lake are the three most downstream reservoirs of a chain of reservoirs on the Colorado River known as the Highland Lakes. These reservoirs are the City's main water supply and serve as major tourism and recreational resources. The public has excellent access to these lakes through several thousand acres of City and County parks as well as private marinas, parks and resorts. The lakes have been classified by the Texas Water Commission as high to exceptional quality aquatic habitat.

Another key water resource in the area is the Edwards Aquifer - a cavernous, faulted limestone aquifer that outcrops on the western side of the City. Barton Springs, widely regarded as Austin's "crown jewel" is the major discharge point of that portion of the Edwards Aquifer which lies southwest of Austin (see Figure 1). During the warmer months of the year, the City operated pool at the springs serves thousands of visitors every day. The spring water flows from the pool into Barton Creek, and eventually into Town Lake where it provides a portion of the City's water supply. The Edwards Aquifer is the sole source of water supply to several small communities south of Austin.

Other limestone aquifers on the western side of the City discharge to numerous small springs and seeps that provide the baseflow to the western creeks. The creeks throughout the City are important recreational resources since the City has over 3000 acres of greenbelt and associated parks. Several of these creeks and the Colorado River below Town Lake are also considered high quality aquatic habitat.

However, it is well known that the value of these resources could easily be impaired by water pollution from stormwater runoff, commonly called nonpoint source pollution. With the support of its environmentally aware citizens, the City has developed one of the best watershed protection programs in the country. The keystone of the program is the Comprehensive Watersheds Ordinance.

This paper provides an overview of the City of Austin's primary means of controlling nonpoint source pollution, the Comprehensive Watersheds Ordinance. It also briefly

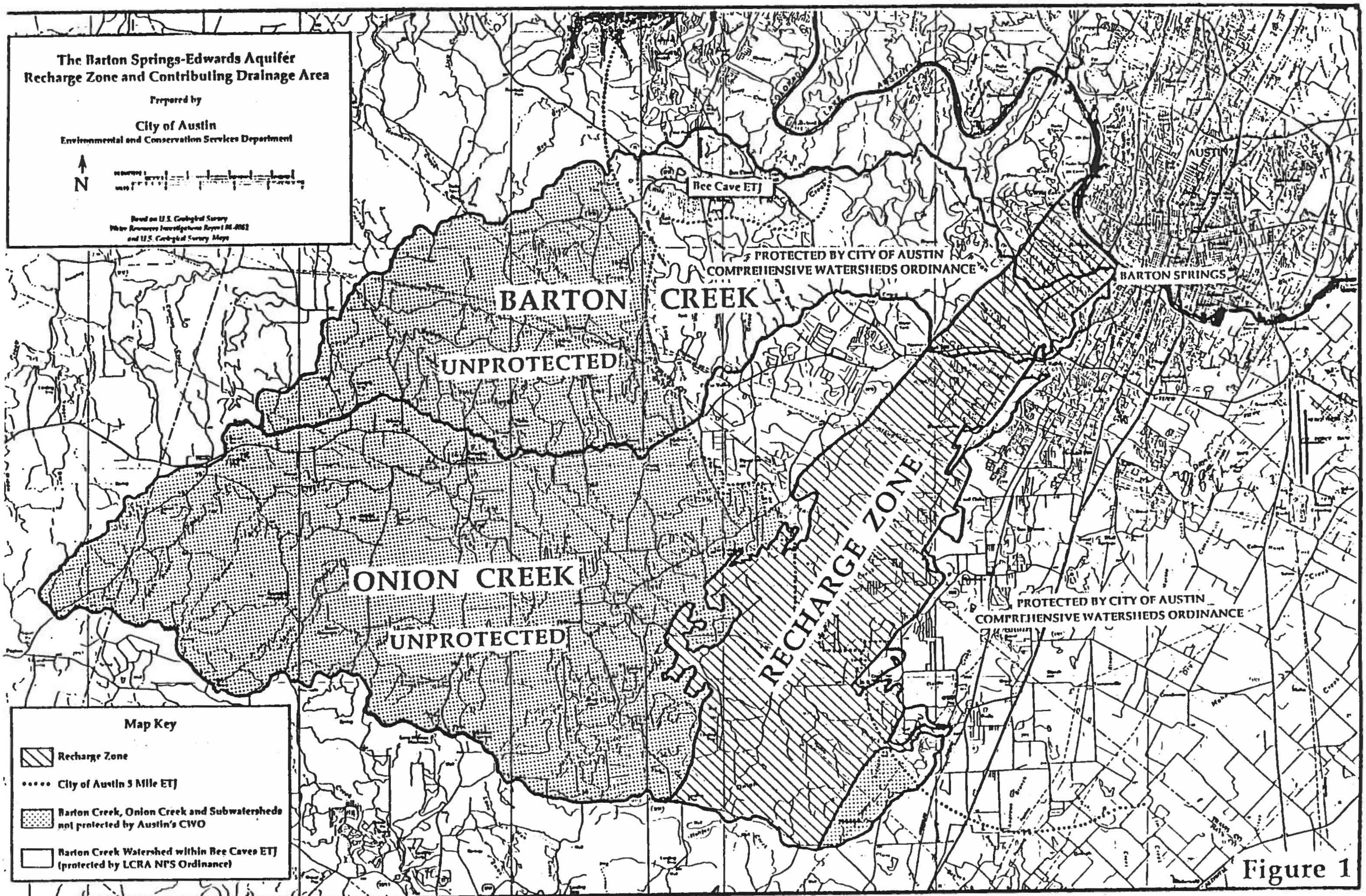

The Barton Springs-Edwards Aquifer
Recharge Zone and Contributing Drainage Area
Prepared by
City of Austin
Environmental and Conservation Services Department
N
Bee Cave ETJ
PROTECTED BY CITY OF AUSTIN
COMPREHENSIVE WATERSHEDS ORDINANCE
BARTON SPRINGS
AUSTIN
BARTON CREEK
UNPROTECTED
ONION CREEK
UNPROTECTED
RECHARGE ZONE
PROTECTED BY CITY OF AUSTIN
COMPREHENSIVE WATERSHEDS ORDINANCE
Map Key
Recharge Zone
City of Austin 5 Mile ETJ
Barton Creek, Onion Creek and Subwatersheds not protected by Austin's CWO
Barton Creek Watershed within Bee Caves ETJ (protected by LCRA NPS Ordinance)

Figure 1

discusses some additional programs that are under way which aid in the effort to reduce pollutant impacts to our lakes and streams. Finally, it discusses two areas of the City that are currently causing the greatest concern for water quality and for entirely different reasons:

- Mitigating significant water quality impacts on Town Lake from the City's urban watersheds and

- Preventing degradation of high quality waters of the Edwards aquifer and the streams that recharge it.

DEVELOPMENT OF ORDINANCE GOALS

The primary goal of the Comprehensive Watersheds Ordinance is to protect the water resources of the Austin area from degradation from nonpoint source water pollution. Other goals include preventing loss of recharge to the Edwards Aquifer and smaller localized aquifers, preventing adverse impacts from wastewater discharges and a general protection of the natural and traditional character of our water resources. These goals have evolved over the years as the City and the nation have become more aware of the numerous potential problems from nonpoint source pollution and from modification of the hydrologic system associated with urbanization.

The potential problem was first studied by the City in 1974 as part of a comprehensive planning effort entitled "Austin Tomorrow". Nonpoint source pollution was identified as a significant potential threat to the environment and to the economic well-being of the City as a whole. This study led to monitoring of the City's creeks and lakes related to nonpoint source pollution and to the development of a series of water quality related ordinances. The Lake Austin Watershed Ordinance (1978) was the first true nonpoint source pollution control ordinance in this region of the country. In 1981, the City participated in the EPA sponsored Nationwide Urban Runoff Study and began a monitoring program of structural controls in 1982. Other watershed ordinances were passed from 1980 to 1984 in order to protect additional sensitive watersheds and to upgrade the level of protection.

By 1986, the City had 8 years of experience with different types of ordinances and had performed several studies on the effects of nonpoint source pollution. Based on this expertise, the City developed the Comprehensive Watersheds Ordinance to enhance the protection of the critical water resources and to extend protection to additional watersheds. Throughout the process of developing the previous ordinances, environmental groups, citizens, developers and the Council-appointed Environmental Board provided input at numerous public hearings and work sessions. A Comprehensive Watersheds Ordinance Task Force was appointed by the City Council to provide the final review and recommendations.

OVERVIEW OF THE ORDINANCE

The Comprehensive Watersheds Ordinance requires a range of widely accepted and proven structural and nonstructural nonpoint source pollution controls to be included in new development projects. These controls include impervious cover limitations, water quality buffer zones, protection of critical environmental features, limitations on disturbance of the natural stream, erosion control practices, sedimentation and filtration basins, and wastewater disposal requirements. Density limitations are also included for residential developments in the most sensitive watersheds. The most important aspect of the Ordinance is the use of nonstructural controls to prevent and mitigate pollution associated with developments. Impervious cover limitations and buffer zone requirements have the best track record nationwide and maintain the basic hydrologic balance of the environment.

The Comprehensive Watershed Ordinance successfully integrates review of environmental requirements for new developments into the City's existing development review processes for zoning, subdivision and site plans. The development plans are reviewed by engineering, scientific and planning professionals of the Environmental and Conservation Services Department. An environmental review staff autonomous from other departments such as Public Works or Planning allows a focused review of the environmental issues. Environmental Assessments are required for water supply watersheds. The review of these projects include field surveys of projects in sensitive areas. Minor variances are allowed from the strict application of the Ordinance when the variance does not result in a significant adverse environmental impact and/or additional mitigative measures are included. Applications for these variances are reviewed by the Environmental Board and the Planning Commission. Once the plans are approved, City inspectors specifically trained with respect to the environmental criteria monitor the construction for compliance with the approved plans.

Targeting of Pollution Controls

The key to a successful nonpoint source control program is targeting of critical areas to achieve high-payoff returns. In the Austin area, the focus is on the potential deterioration of the local water supplies - Lake Travis, Lake Austin, Town Lake, and the Edwards Aquifer. Lakes are particularly susceptible to adverse effects from nonpoint source pollution and some of these effects were documented in previous studies. The Edwards Aquifer is also highly susceptible to adverse effects from nonpoint source pollution since the geologic formation is a cavernous, faulted, limestone with limited capability to remove pollutants. The Comprehensive Watersheds Ordinance requires the strongest nonpoint source controls in developments in those watersheds which contribute to our water supply. The water supply watersheds are located on the western side of the City where the geology is primarily karst limestone. In addition to the water quality issue, the need to maintain recharge quantity to the Edwards Aquifer and the other limestone formations has been identified as a key goal in protecting the environment in these areas. The required controls also result in the protection of recreational value and high quality wildlife habitat of these creeks and lakes.

Protection of non-water supply watersheds to the east of Austin was not given priority in the Ordinance for several reasons. Downstream of Town Lake, the Colorado river is not used for drinking water supply. It was also recognized that the effects of nonpoint source pollution on free flowing streams and rivers are not as serious as for lakes. The soils and geology on the eastern side of the City is dominated by clay; therefore, maintaining infiltration and recharge was not a critical goal in these watersheds.

New development was targeted by the Ordinance as the most cost-effective method of preventing future problems from nonpoint source pollution. The required controls are prescribed in the Ordinance so they can be included in any initial land planning. Since the key controls are nonstructural, the main cost is related to the raw land cost. Existing developments are exempt since the goal of the ordinance is prevention, not restoration. Retrofitting existing developments has proven to be particularly difficult since the most important nonstructural controls, such as impervious cover limitations, are not applicable. Also retrofitting structural controls is very expensive due to limited locations and high land costs.

Ordinance Components and Effectiveness

The long-term prevention of adverse water quality impacts will be the overall measure of effectiveness of the Comprehensive Watersheds Ordinance. Since it is the cumulative effect of increasing pollutants that causes water quality problems, the Comprehensive Watershed Ordinance was designed to effectively and fairly reduce pollution on a tract by tract basis. The components of the Ordinance have been proven to reduce or prevent pollution on both nationwide and local levels. The complete package of nonpoint source components are considered "Best Management Practices" (BMPs) and provide a reasonable assurance that future water quality is protected.

Nonstructural controls are emphasized by the Ordinance since these provide the greatest certainty of protection with the least maintenance requirements. The impervious cover limitations are the most important component of the nonpoint source pollution controls since nationwide research has consistently documented increased pollutant loads with increasing impervious cover. This relationship has been verified by the City's own nonpoint source monitoring program. In March of 1990, the City published "Stormwater Pollutant Loading Characteristics for Various Land Uses in the Austin Area". This document verifies for the Austin area that NPS pollutant loads increase significantly with impervious cover. The pollutant parameters that have a documented increase in load with impervious cover include total suspended solids, organics, nutrients, coliform bacteria and heavy metals. Of particular interest are the parameters chemical oxygen demand (COD), total nitrogen (TN), Total Phosphate(TPO4) and Total Suspended Solids (TSS). These parameters show a significant increase at high impervious cover (Figures 2 - 5). The most serious

Figure 2. Impervious Cover vs COD Loading

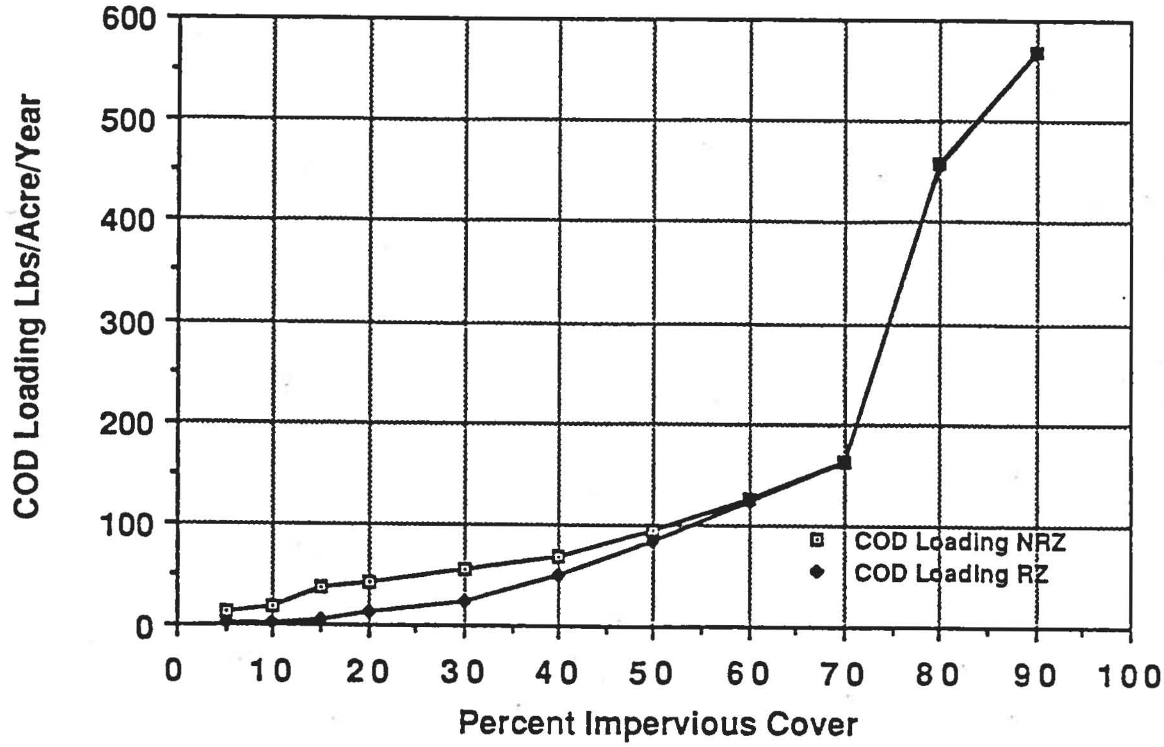


Figure 3. Impervious Cover vs TN Loading

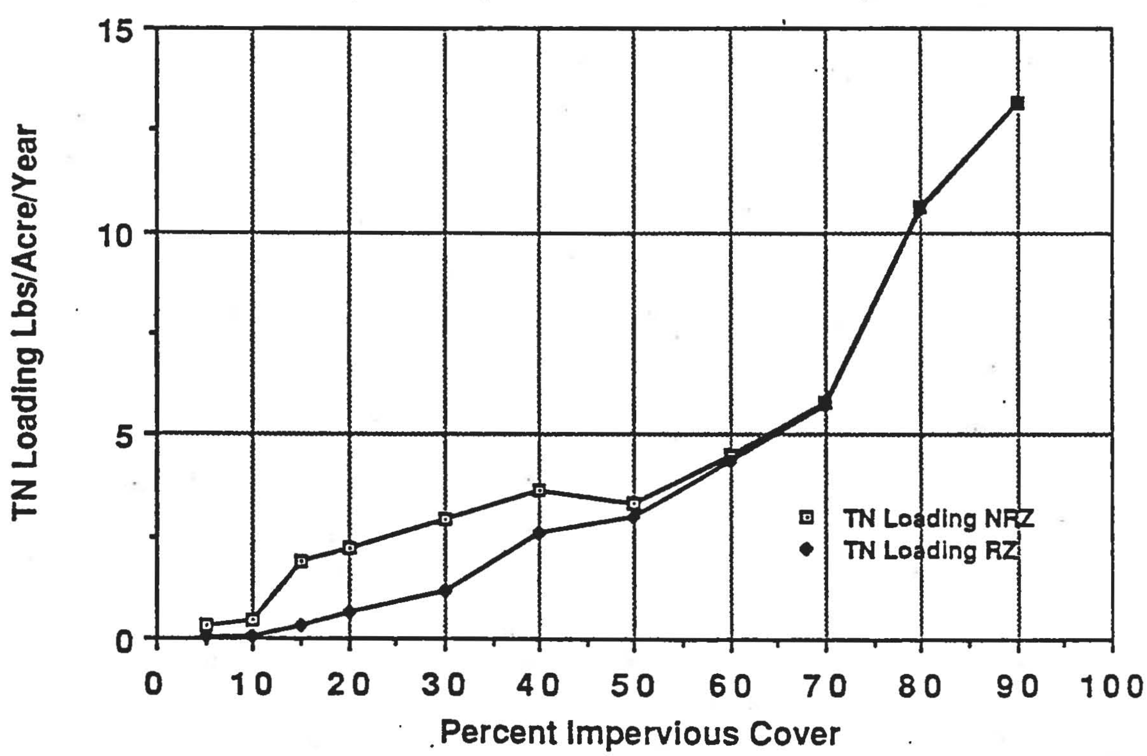


Figure 4. Impervious Cover vs TPO4 Loading

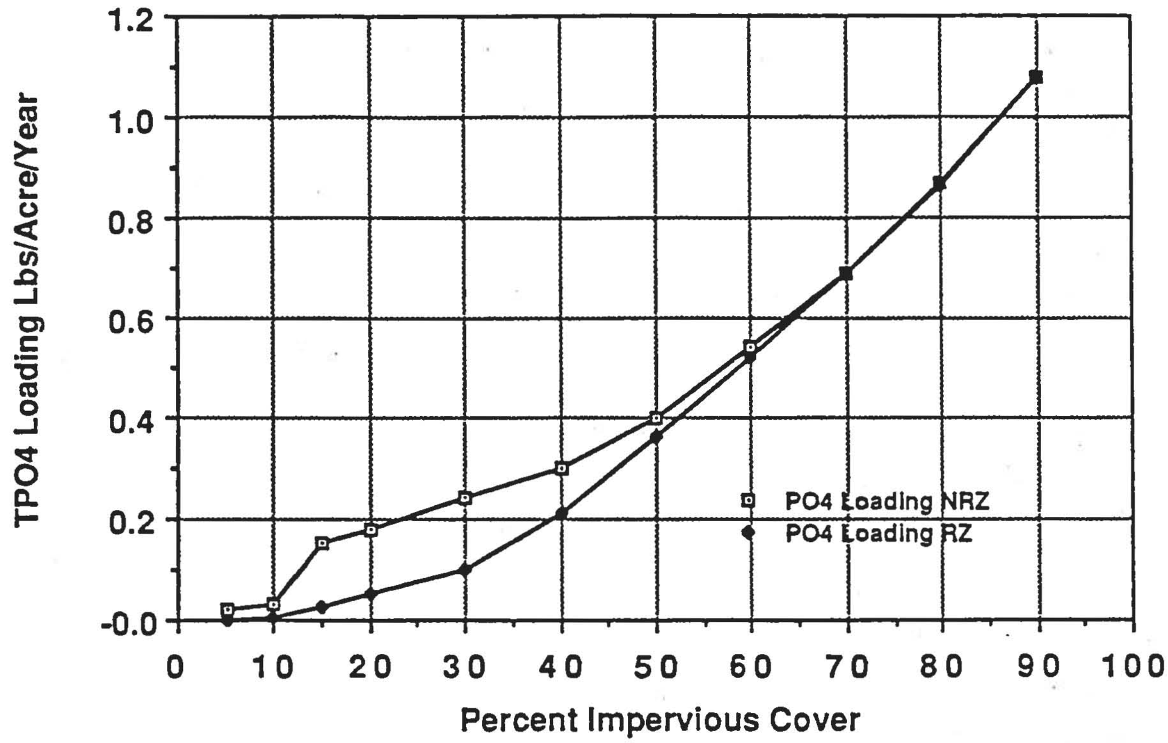
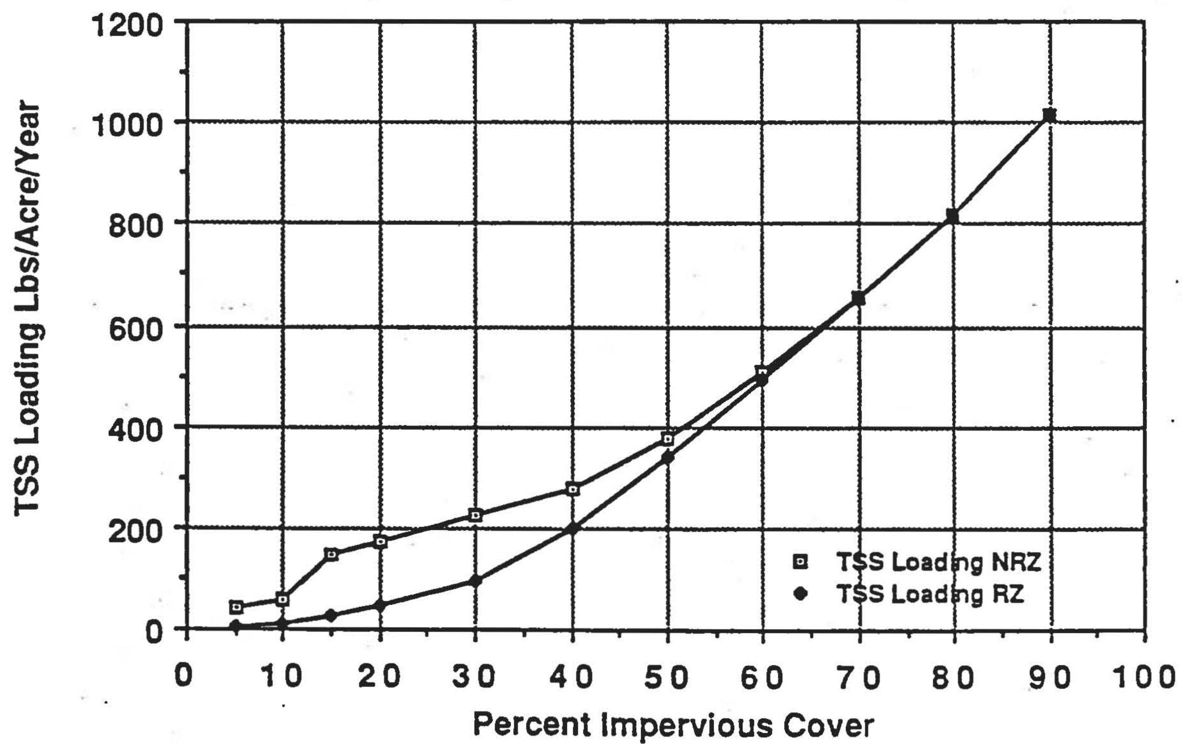


Figure 5. Impervious Cover vs TSS Loading



potential impacts from the resulting increase in loads is in multi-purpose reservoirs and in aquifers; therefore, impervious cover is limited the most in the western water supply watersheds.

The impervious cover limitations also serve to maintain some of the natural infiltration, especially critical to the nature of the western watershed systems. During heavy rainfalls the water infiltrates down to either small localized ground water systems or to major aquifers. This infiltration is the source of the flow for numerous small springs and seeps which provide flow to the local creeks for months after a storm event. This high quality ground water return flow is essential for the preservation of the hydrologic and ecologic systems in the area.

Vegetated buffer zones are required adjacent to creeks and around critical environmental features such as springs, seeps, bluffs, canyon rimrocks, wetlands, faults, caves and sinkholes. These buffers range in width depending on the sensitivity of the watershed and the associated hydrologic features. In the most sensitive watersheds, a 40% buffer is required downstream of developments. Although buffer zones are a proven method of pollution control, the City and Texas A&M University are jointly monitoring buffer zones to further document their effectiveness with respect to urban runoff.

The Ordinance requires a variety of controls related to erosion and sedimentation control. The most important erosion controls are preventative. These include limitations on the depth of cuts and fills, limitations on amount of construction on steep slopes (greater than 15%) and limitations to disturbance of the natural stream including restrictions on the number of creek crossings. Temporary erosion controls are required during construction such as silt fences and rock berms. There are also requirements related to spoil disposal and the area of site disturbance. These controls are particularly important to prevent siltation of the reservoirs and to prevent clogging of the aquifer recharge features.

Sedimentation and filtration ponds are required for developments of higher intensity, particularly commercial developments. The City has developed a design which requires the first half inch of runoff from the site to be diverted into a sedimentation basin and then filtered through a sand filter. This design is based on 8 years of monitoring filter ponds of different designs. The removal efficiency for total suspended solids is 75% to 97%. Where appropriate, wet ponds can be substituted for the sedimentation/filtration ponds. Wet ponds have been proven to be effective in other parts of the country.

Structural controls are not solely relied upon because of the complexity of stormwater runoff and the limited data on the effectiveness of the controls. Numerous factors, such as traffic volumes, parking frequency, type of impervious cover, population density, land use, soil and slope factors, and landscape treatments, make it impossible to predict precisely the pollutant characteristics of at a given site. Although structural controls have been shown to reduce pollutants a given site, the available data indicates that structural controls alone cannot prevent an increase in pollutants from high intensity developments. Monitoring and analysis of pollutant loading data and structural controls have only occurred intensively locally and nationwide for less than 10 years; therefore, there is a greater uncertainty related to the effectiveness of structural controls than there is with the nonstructural controls described above. Structural controls are relatively unproven in effectiveness for some important parameters such as dissolved nutrients. This uncertainty is critical with respect to reservoir watersheds since increased concentrations of dissolved nutrients can cause excessive algae growths which can lead to taste and odor problems in drinking water. Maintenance requirements are high for structural controls compared to impervious cover limitations and buffer zones. Maintenance is critical to ensure effectiveness, and providing proper and timely maintenance has been a local and nationwide problem. Additionally, the potential for higher toxic loads exists for higher density developments with structural controls than for lower density developments. The combination of nonstructural and structural controls of the Comprehensive Watersheds Ordinance is intended to provide a higher factor of safety for protection of the City's water resources than could be provided by the sole dependence on structural controls.

Costs and Financing

The implementation of the program is funded through several sources. Approximately 50% of the expenses related to reviews and inspections is covered by various development permit fees. The fees vary depending on the size of the tract and the increased review required for projects in sensitive watersheds. The remaining review and inspection expenses are funded by the general fund. Water quality research and monitoring is funded by a drainage fee assessed throughout the City. Each development pays for the costs of implementing the controls associated with that development. Since the primary methods of control are nonstructural the costs to the City with respect to monitoring and inspection are considerably lower than if structural controls alone were used.

It should be noted that preventing adverse water quality impacts from nonpoint source pollution is much less expensive than trying to restore water quality after problems have occurred. One of the goals of the Comprehensive Watersheds Ordinance is to avoid the expense of retrofitting existing developments. Preventing nonpoint source pollution also reduces, avoids or significantly delays other costs. City revenues from park concessions are reduced by nonpoint source pollution and maintenance costs at the parks are increased. The operations costs at the water treatment plants go up after storm events and taste and odor problems occur during algae blooms in the lakes. Sediment carried in runoff is gradually filling the lakes and could require expensive dredging if erosion in the watershed is not controlled. Toxics from areas of the City developed decades before the Ordinance was in place have resulted in a health advisory for eating some types of fish from Town Lake. Although the avoided costs are difficult to quantify, the potential cost and difficulties related to restoration, retrofitting, dredging, advanced water treatment, development of new water supplies and lost recreational value easily justifies the cost related to the Ordinance.

Transferability

The Comprehensive Watersheds Ordinance is easily transferable to other jurisdictions and hydrogeologic conditions. The Town of Lakeway adjacent to Lake Travis adopted a watershed ordinance using the same basic framework and components of the Comprehensive Watersheds Ordinance. The City of Del Rio also used the Comprehensive Watersheds Ordinance as a general guide to ordinances and subdivision regulations designed to protect their main water supply, San Felipe Springs, which is the major spring discharging from a limestone aquifer. The Texas Water Commission used the Comprehensive Watershed Ordinance as an example of the kinds of controls the local governments could implement as part of its Nonpoint Source Management Plan submitted to EPA. Numerous governmental entities throughout the country have been provided copies of the Comprehensive Watersheds Ordinance upon their request for information on how to protect their water resources.

The Comprehensive Watersheds Ordinance provides protection for a range of watersheds, from very sensitive water supply watersheds to watersheds that would not be greatly impacted by nonpoint source pollution. Other cities can easily adopt the portions of the ordinance that apply to the types of geology, ecology, receiving waters and the types of use for their city. Because the Ordinance is based on "Best Management Practices" instead of design or performance standards, it does not require any specialized staff or consultants for implementation. Planners or engineers that typically work for city public works departments or planning departments have a sufficient knowledge to perform the reviews. More specialized staff or consultants may be needed to determine the level of protection for sensitive watersheds at the inception of the program and to identify critical environmental features. It also is fairly easy for developers, engineers, and planners to implement since it does not require any specialized expertise in water quality. Besides the Ordinance, the City has developed an Environmental Criteria Manual, which serves as a technical backup to the controls required by the Ordinance.

ADDITIONAL POLLUTION PREVENTION PROGRAMS

Home Chemical Collection Day

For the past five years, the City of Austin has conducted annual home chemical collection days which provide an opportunity for safe and legal disposal of home chemical which otherwise might end up in the storm sewer, creek, sanitary sewer or landfill. A broad range of household chemicals and waste products are accepted including pesticides, caustics, cleaners, waste oil, paint and other items. Recyclable materials such as paint are donated to group which use them for their intended purpose. Waste oil is recycled as well. All hazardous materials are packed and shipped for legal disposal by various methods. This year we are moving toward a permanent facility that will open periodically throughout the years to come.

Hazardous Spill and Water Quality Complaint Response

The Austin Fire Department has a Hazardous Materials Response Unit that responds to hazardous material spills. They contain the spilled material and eliminate the threat of harm from the material to public health and welfare. The Environmental and Conservation Services Department (ECSD) assists by attempting to determine the party responsible for the release of hazardous or polluting materials in order to have them clean up the materials and repair any damage which may have been caused. ECSD also responds to citizen complaints of water quality problems and attempts to have them resolved in the same manner

Storm Sewer Discharge Permit Program

The Environmental and Conservation Services Department conducts a program of annual inspection and permitting of facilities discharging industrial contaminated stormwater runoff to storm sewers or waterways. Currently, the program covers over 500 facilities, mostly associated with automobile repair and servicing. This program has resulted in the re-routing of several bay drains to the sanitary sewer which is covered by another ordinance. Facilities are inspected to ensure that housekeeping measures are followed to minimize the amounts of pollutants that may be available to be washed off impervious surfaces during storms.

Xeriscape and Integrated Pest Management Programs

These two program discourage the use of fertilizers and pesticides or at least encourage minimal use of the least harmful varieties of these chemicals. Xeriscape encourages the use of landscape plantings which are adapted to the area and have lesser needs for fertilizers and pesticides to compete with the undesirable plants. Use of mulches is encouraged rather than herbicides to keep weed growth suppressed.

CURRENT AREAS OF GREATEST CONCERN

Town Lake Water Quality

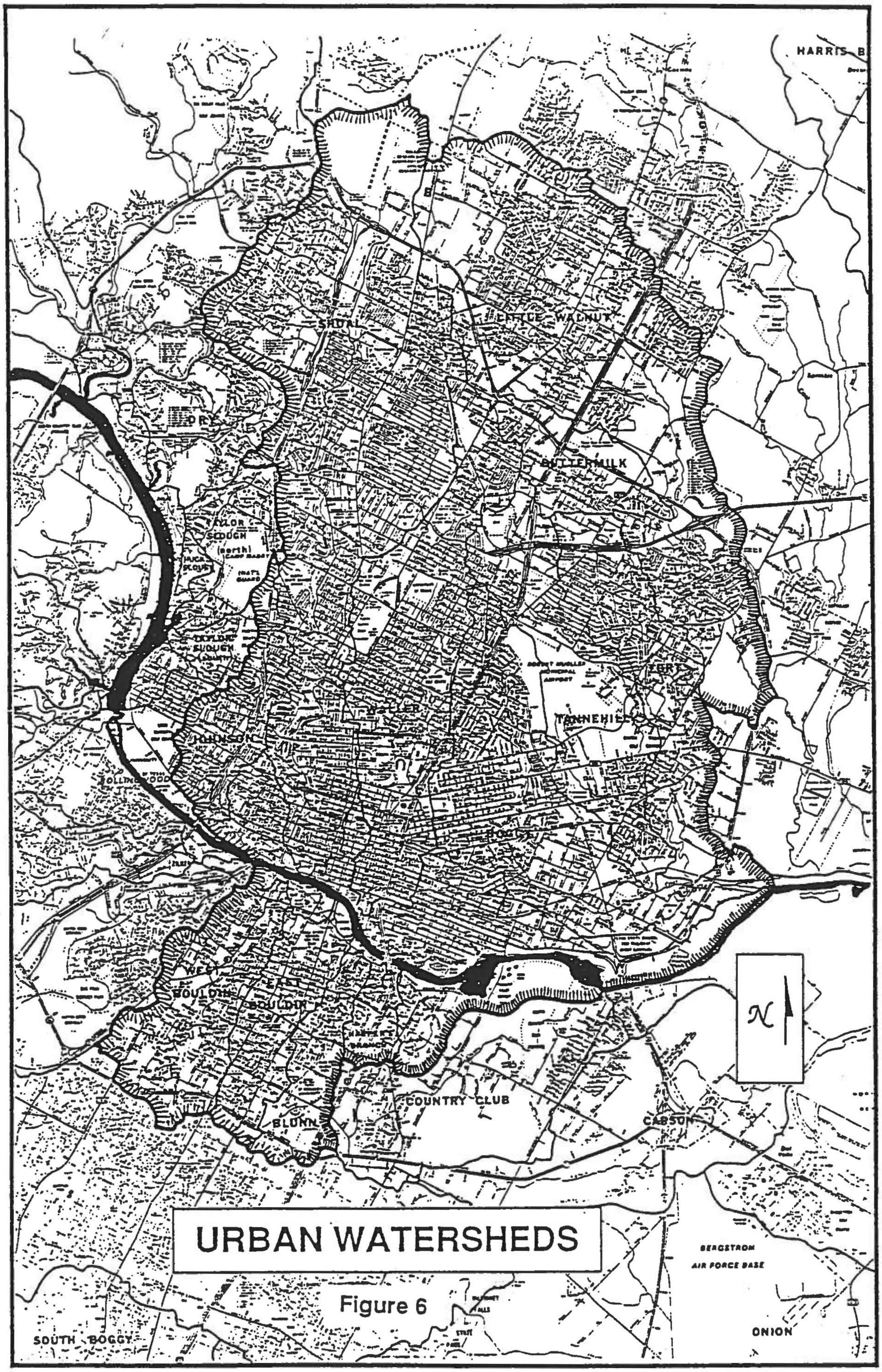
Town Lake is significantly impacted by nonpoint source pollution from mostly developed "urban watersheds" (Figure 6). The most visible evidence of this is the presence of large amounts of sediment and floating debris in the lake after large storm events. Not visible are the nutrients and toxic pollutants that also reach the lake during storm events. The effects of these pollutants are inversely related to the release rate from the upstream Lake Austin. During the period of late spring to early fall, release rates are high to supply water to downstream rice growers and so visible impacts of the runoff are relatively short-lived. During the winter months, residence times of water in the lake are long and as a consequence, nonpoint source impacts can be more severe.

There are no significant permitted point source pollution discharges contributing to the Town Lake Watershed or the segments immediately upstream; therefore, most of the pollutant load is related to nonpoint source pollution (although urban stormwater from a municipal stormsewer system is considered a point source by EPA). The City participated in the Nationwide Urban Runoff Program (NURP) in 1981. That study concluded that short-term effects of runoff-generated pollutants such as biochemical oxygen demand, ammonia, total suspended solids, phosphates and fecal coliforms can be significant under certain hydrologic conditions. The presence of floatable pollutants such as trash, debris and oil was observed after storm events. The NURP study also indicated that concentrations of lead in the sediments were higher in Town Lake than in Lake Austin and attributed the difference to urban runoff. A review of sediment data from 1988 done for this proposal indicates the lead concentrations in sediment are over 2 times higher in Town Lake than in Lake Austin (Figure 7).

The 1988 report by USGS prepared in cooperation with the City of Austin, "Water Quality of Lake Austin and Town Lake", indicated that high fecal coliform densities were primarily related to runoff events and that there was an apparent increase in densities at the downstream stations.

The City presented a "Preliminary Analysis of Nonpoint Source Pollution Effects on Town Lake" at the North American Lake Management Society, 9th Annual International Symposium on Lake & Reservoir Management, 1989. This analysis indicates that the high fecal coliform and fecal streptococci densities in Town Lake after storm events appear to be primarily related to animal sources based on a typical ratio of 1:1. The preliminary analysis also identified 3 algae bloom events, one of which occurred in March of 1989 after a small localized rainfall/runoff event in the urban watersheds. A preliminary NPS loading analysis indicated that phosphorus and nitrogen loadings are in the range where eutrophication is a potential problem. Significant amounts of trash, debris and sediment were observed in all the urban creeks and Town Lake after several storms in 1989. At the mouths of several urban creeks, including Waller Creek, deltas are continuing to build out into the lake. Rooted aquatic plants were abundant in the shallow areas of these deltas.

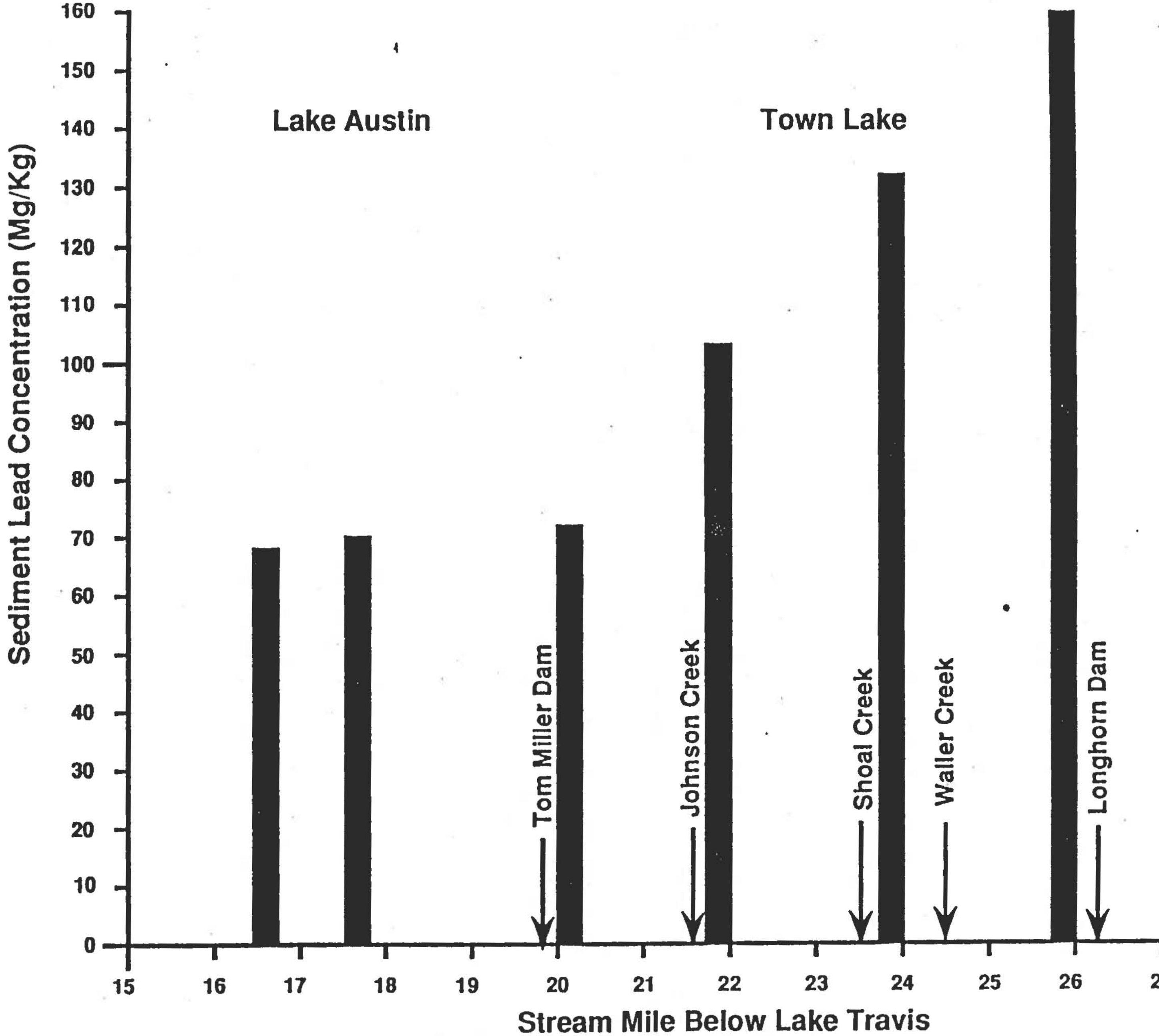
Perhaps most significantly, this analysis also documented that 17 different insecticides and herbicides had been detected in stormwater in Shoal Creek, the largest urbanized tributary to Town Lake. Some of these same compounds were also detected in Town Lake and Barton Creek. Also, chlordane has been detected in fish collected from Town Lake which prompted a joint health advisory to be issued by the State Health Department and Austin-Travis County Health Department and also prompted inclusion of Town Lake in the Texas Water Commission's and EPA's 304(L), "Comprehensive List" of waters effected by toxics.



URBAN WATERSHEDS

Figure 6

Figure 7. Sediment Lead Concentration Plot by Stream Mile Below Lake Travis



Oil, grease and lead are pollutants typically associated with NPS pollution from high traffic urbanized areas. COD, TOC and lead concentrations at the City's Barton Creek Square Mall (BCSM) monitoring site were evaluated to provide some indications of the magnitude of these pollutants for the highly urbanized areas targeted for this project. The first samples taken from each storm typically had about double the mean storm concentration for these parameters with some values 10 times the mean. The COD geometric mean of event mean concentrations (EMCs) is 42 mg/L; however, the mean for the first samples taken from each storm was 69 mg/L and ranged as high as 330 mg/L. The TOC geometric mean of event mean concentrations (EMCs) is 11 mg/L; however, the mean for the first samples taken from each storm was 24 mg/L. The lead geometric mean is 0.03 mg/L; however, the mean for the first samples taken from each storm was 0.06 mg/L and ranged as high as 0.29 mg/L.

Controlling NPS pollution from urbanized watersheds is particularly difficult. Two of the BMPs used in our developing watershed, impervious cover limitations and buffer zones are typically not applicable in watersheds with existing development. The initial work on the Clean Lakes Study indicates that there is no significant state or national experience on retrofitting BMPs to urban areas. Structural BMPs are typically very costly since both construction and land costs are increased by the limited number of sites. Nonstructural controls such as street sweeping have had very limited success in urban watersheds. Controls including waste minimization and public education are generally considered to be effective but are difficult to quantify in terms of improved water quality. Also, there is very limited data on storm loads from high density commercial areas and the costs and benefits of various structural control measures for theses areas.

Reducing NPS pollution from developed watersheds is much more complex than preventing NPS problems in developing watersheds. One key problem in developed watersheds is the increased channel erosion and the corresponding increase in sediment that is a direct result of higher peak flows from increased impervious cover and "improved" stormwater conveyances. Reduced baseflow is also an important hydrologic impact of urbanized areas that effects NPS problems. Controlling nutrients are also a problem. One of the best BMPs for controlling nutrient are wet ponds; however, wet ponds are particularly difficult to site under retrofit conditions. Toxics are problems for several reasons. First, they are difficult and expensive to detect. Second, even though some uses have been banned or restricted, such as Chlordane and Lead, the substances still occur from years of use in soil and sediment in the creeks and lakes.

The City of Austin is conducting a Phase I Diagnostic/Feasibility Study of Town Lake as part of the federal Clean Lakes Assistance Program. Mitigation of stormwater pollution from urban watersheds and particularly the urban core is a complex issue requiring significant study and, ultimately, significant expense.

As an interim step, an Urban Watersheds Ordinance has been prepared and submitted to the Austin City Council. This proposed ordinance is similar to the Comprehensive Watersheds Ordinance in that it calls on new development to mitigate the new pollution that it will generate, but would affect existing pollutant loads only to the extent that major redevelopment occurs. Currently less than 17% of the urban watersheds is undeveloped, so at best this ordinance would only help to keep the water quality impacts to Town Lake from getting worse. Water quality improvement in Town Lake will come out of the results of the Clean Lakes Study and will likely involve a combination of retrofitting of structural controls by the City and source control programs such as public education on fertilizer and pesticide application. The City is conducting a screening of the Urban Watersheds to find suitable locations for structural stormwater control retrofits. One such retrofit is being incorporated in to the new downtown Convention Center. This wet-pond type control will treat runoff from the Convention Center and seventeen acres of the surrounding downtown area. The new NPDES stormwater regulations will help in that they call for a systematic approach to determining the sources of pollutant impact through searching for illicit connections to the storm sewers and they will help with enforcement of problem discharges from industries and commercial operations.

Protection of the Barton Springs Segment of the Edwards Aquifer and Its Contributing Watersheds

The water quality in the creeks recharging the Barton Springs segment of the Edwards aquifer is still exceptionally good in the portions of watersheds which have not yet been substantially developed. High quality waters, however, are quick to show the effects of additional amounts of pollutants by such measures as increased productivity from the addition of nutrients and decreased diversity of aquatic life from the addition of toxic pollutants. Barton Creek and other contributing zone creeks are already showing the impacts of additional pollutant loads from developed areas. A study by the U.S. Geological Survey covering the period of 1978 to 1987, shows that average stormflow concentrations increased from upstream (less developed watershed) to downstream (more developed watershed) stations in Barton Creek. The data from the USGS Barton Creek at Loop 360 station since 1987 show an increase in nitrate and Biochemical Oxygen Demand over previous years. These monitoring results show the beginnings of water quality degradation in the middle reaches of Barton Creek.

As has been previously discussed, the City of Austin's Land Development Code contains watershed regulations that protect the water quality of local creeks and the Colorado River. While these regulations are some of the most effective in the country, they are not sufficient to prevent degradation of high quality waters in the Barton Springs segment of the Edwards Aquifer and its contributing zone. On October 4, 1990 the Austin City Council adopted a resolution calling for staff to develop a strategy for prevention of water quality degradation in Barton Creek. The staff has proposed a nondegradation strategy for all watersheds contributing to Barton Springs, designated as the Barton Springs Contributing Zone (Figure 8). While Barton Creek has the most immediate effect on the quality of water in Barton Springs, ultimately, recharge water from every creek which crosses the recharge zone affects the quality of water in the aquifer and the springs. More stringent controls are needed throughout the contributing and recharge zones of the Barton Springs segment of the Edwards Aquifer in order to prevent degradation of the these important natural resources.

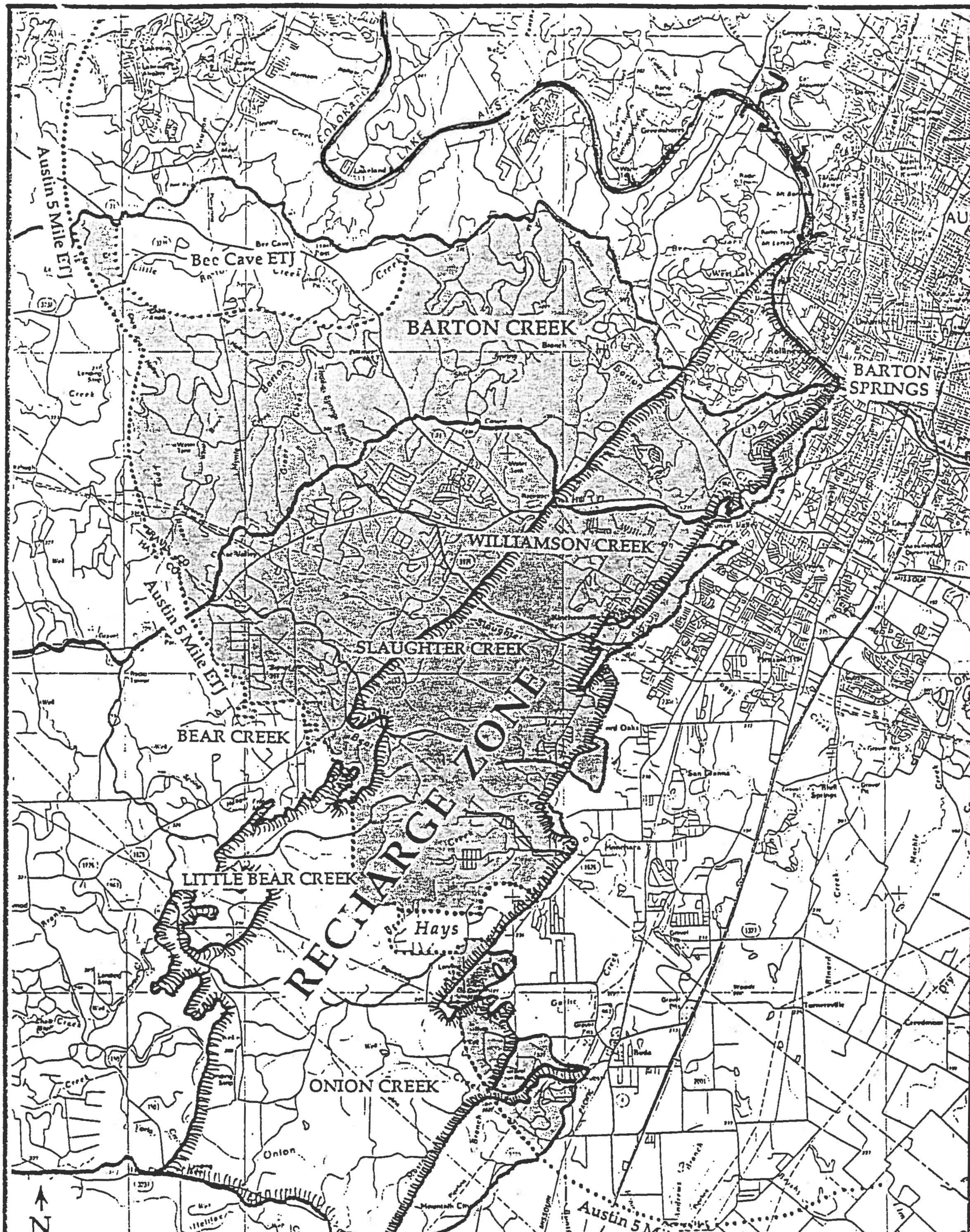
The City of Austin Comprehensive Watersheds Ordinance (Now codified in the Land Development Code) uses a combination of stormwater treatment practices (water quality control basins and vegetative buffer zones) and limitations on percent impervious cover to achieve its water quality goals. Although these current controls substantially reduce the pollutants which otherwise would be discharged from developments, they still allow the discharge of pollutant loads from regulated development at levels in excess of background. These additional pounds of pollutants are likely to lead to appreciable degradation of the high quality waters in Barton Springs and its contributing creeks.

The proposed City of Austin nondegradation strategy for Barton Springs and its contributing watersheds is:

- **to eliminate the adverse water quality impacts of new development by limiting post-development loads, or pounds of pollutants discharged per acre per year, to pre-development background levels.**
- **to achieve this zero increase in pollutant loads by limiting percent impervious cover to levels at which generated pollutant loads can be reduced to background levels by an expanded menu of stormwater treatment practices;**
- **to strengthen and clarify the existing regulations by limiting exemptions, establishing a water quality criterion for variances and revising weak or conflicting language; and**
- **to reduce the adverse water quality impacts of existing and approved development through a City-funded program of retrofitting stormwater control measures.**

The City of Austin's strategy for nondegradation of Barton Springs and its contributing watersheds is a "Design-based" strategy rather than a totally Technology-based or Performance-based strategy. It optimizes these two traditional strategies by retaining the security of the technology-based approach, which requires that compliance must be designed into the project before it is built based upon best available scientific and engineering principles, and by adopting the results-oriented water quality standards approach, which bases the level of treatment required upon the resultant water quality desired by the community.

Achieving the goal of nondegradation of water quality in these watersheds which flow to Barton Springs means, at a minimum, that additional amounts of pollutant must be



Area affected by ordinance amendment

Figure 8

prevented from being discharged to these waters. This can be accomplished by striking a balance between the additional pollutant loads generated by development, as represented by impervious cover, and the ability of stormwater treatment measures to remove the additional pollutant loads that are generated. By limiting impervious cover to levels at which stormwater treatment practices can reduce generated pollutants to pre-development load levels, additional pollutants which would degrade water quality are prevented from being discharged to the creeks and aquifer.

The proposed strategy to achieve nondegradation in the Barton Springs and its contributing watersheds is to limit percent impervious cover in new development to levels at which post-development pollutant loads, or pounds of pollutants discharged per acre per year, can be reduced to pre-development background levels by an expanded menu of stormwater treatment practices and to undertake a program of retrofitting stormwater treatment measures in areas that are already developed.

Indicator pollutants, Total Suspended Solids, (TSS), Total Phosphate (TPO4), Total Nitrogen (TN) and Chemical Oxygen Demand (COD), are proposed to be the criteria used to define compliance with the nondegradation strategy. Control of these pollutants would result in effective control of most, if not all, other nonpoint source pollutants. These pollutants were selected not only because they adversely impact water quality but also because they represent other pollutants in stormwater runoff. These indicator pollutants vary in their effect on the receiving water, their propensity for occurring in the dissolved versus particulate state, their association with various land use types and their difficulty of removal by the various stormwater treatment measures.

This strategy is proposed to be built into the existing framework of the City of Austin Land Development Code. It is part of the strategy to establish caps on impervious cover as are currently in place. The impervious cover caps would be established by setting the Maximum Sustainable Removal Rate for stormwater treatment measures at 90%, beyond which stormwater treatment measures cannot be relied upon to reduce the pollutant loads associated with additional impervious cover down to pre-development levels. This is a safety factor in part because not enough is known about the use of stormwater treatment measures in series, as would be necessary at even moderate levels of impervious cover, to support very high combined removal efficiencies and in part because treatment measures carry higher risk of failure over the long run than impervious cover limitations. Excessive reliance upon stormwater treatment measures carries with it the risk of failure in the long run because stormwater treatment measures must be maintained, their use and upkeep must be monitored over their design life and they must be replaced when they exceed their design life. Impervious cover levels, on the other hand, do not change over time, require no maintenance and have no design life so long as their limits are not changed and are enforced. Pollutant loads for certain pollutants increase only slightly as a development ages and pavements begin to deteriorate.

Figures 9 through 12 show pollutant removals that would be required for various levels of impervious cover for residential and commercial sites. Different removals would be required for projects over the recharge zone and not over the recharge zone. The difference in removals required for these two land types is the runoff coefficient of the undisturbed land. Because of high infiltration over the recharge zone, runoff volume and hence pollutant loads are very low from undisturbed land. Greater removals are required to reach these lower background pollutant loads. Also, development over the recharge zone presents a greater risk that generated pollutants will be recharged directly to the aquifer without benefit of treatment. As can be seen, required removal rates increase rapidly for impervious cover levels of up to 20% and then begin to level off at removals in excess of 75 to 90%.

During the past ten years, significant strides have been made in the design and use of stormwater treatment techniques, or best management practices (BMPs), for the mitigation of urban nonpoint pollution. More is known about the ability of these techniques to remove pollutants from stormwater runoff, and about their limitations, particularly with respect to their need for maintenance. In May 1990, the City published a report entitled "Removal Efficiencies of Stormwater Control Structures". Figure 11 summarizes expected removal efficiencies for several structural control types and designs.

Few, if any, individual stormwater treatment practices can achieve the removals required for impervious cover levels in excess of 20%. Additionally, annual removal rates will be reduced to the extent that capture volume of the controls falls short of total annual runoff. Controls in series would be necessary to achieve higher levels of impervious cover. It is extremely unlikely that the removal efficiencies for controls in series are additive. Rather they are probably limited by the ability of the processes involved in the subsequent controls to act upon the physical and chemical characteristics of the remaining pollutants. The standard removals which would be allowed under this nondegradation strategy would be based upon best engineering judgment in evaluating how effectively these processes should be able to act upon the pollutants remaining in the pretreated stormwater.

Under the proposed regulations, Nondegradation Water Pollution Abatement Plans would be required to be submitted by all development proposed within the Barton Springs Contributing Zone as part of subdivisions, site plans and land use plans. These plans would outline the steps the applicant plans to take to meet the nondegradation standard using the annual pollutant load and annual pollutant removal efficiency calculation methodologies which are proposed to be outlined in the Environmental Criteria Manual. Although preparation of these plans would take additional effort beyond what is currently required, the plans are not intended to be duplication of other parts of the application process and would not run counter to the streamlined development review process. All factors pertaining to the proposed design to meet the nondegradation strategy would be concentrated in a single short document and not mixed with design components for other purposes such as flood

Figure 9. Removal Rates to Achieve Nondegradation for Residential Land Use over the Recharge Zone

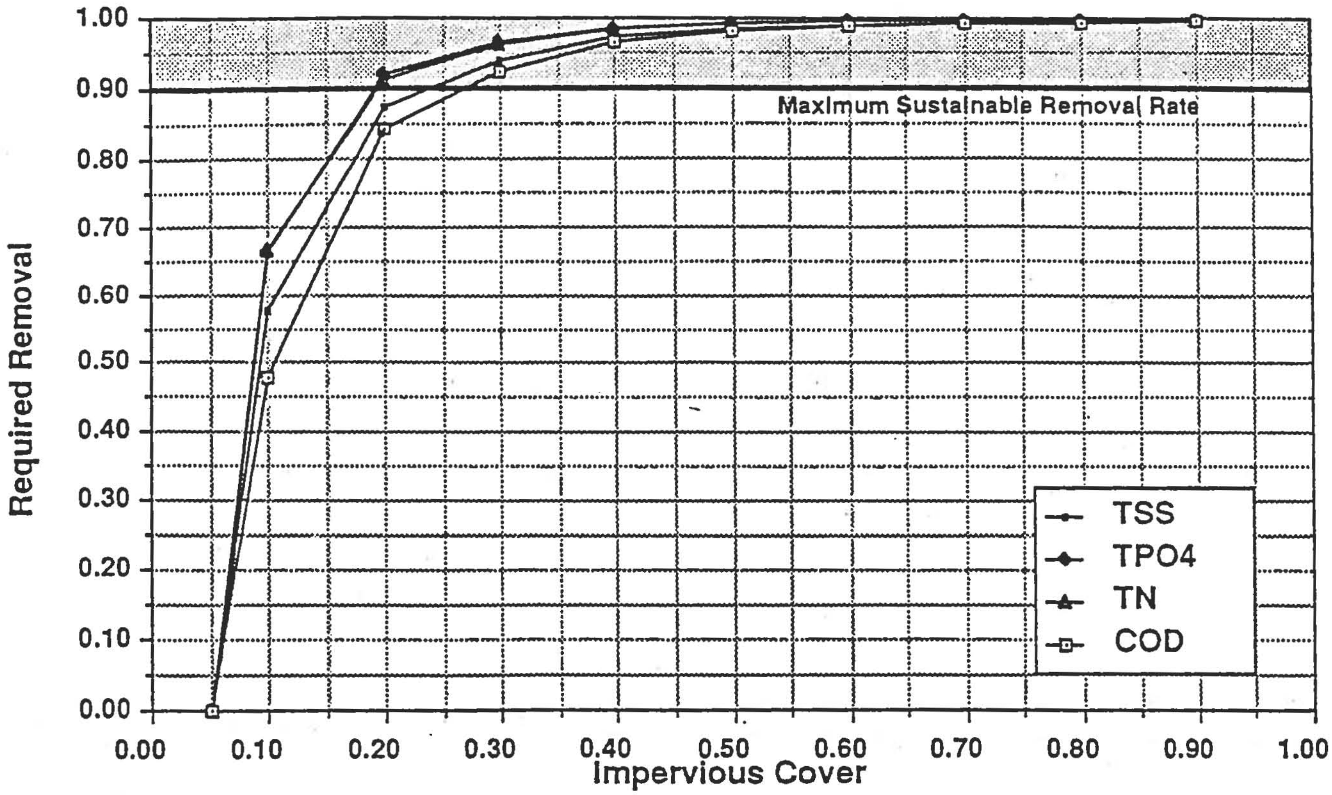


Figure 10. Removal Rates to Achieve Nondegradation for Residential Land Use for the Non-Recharge Zone

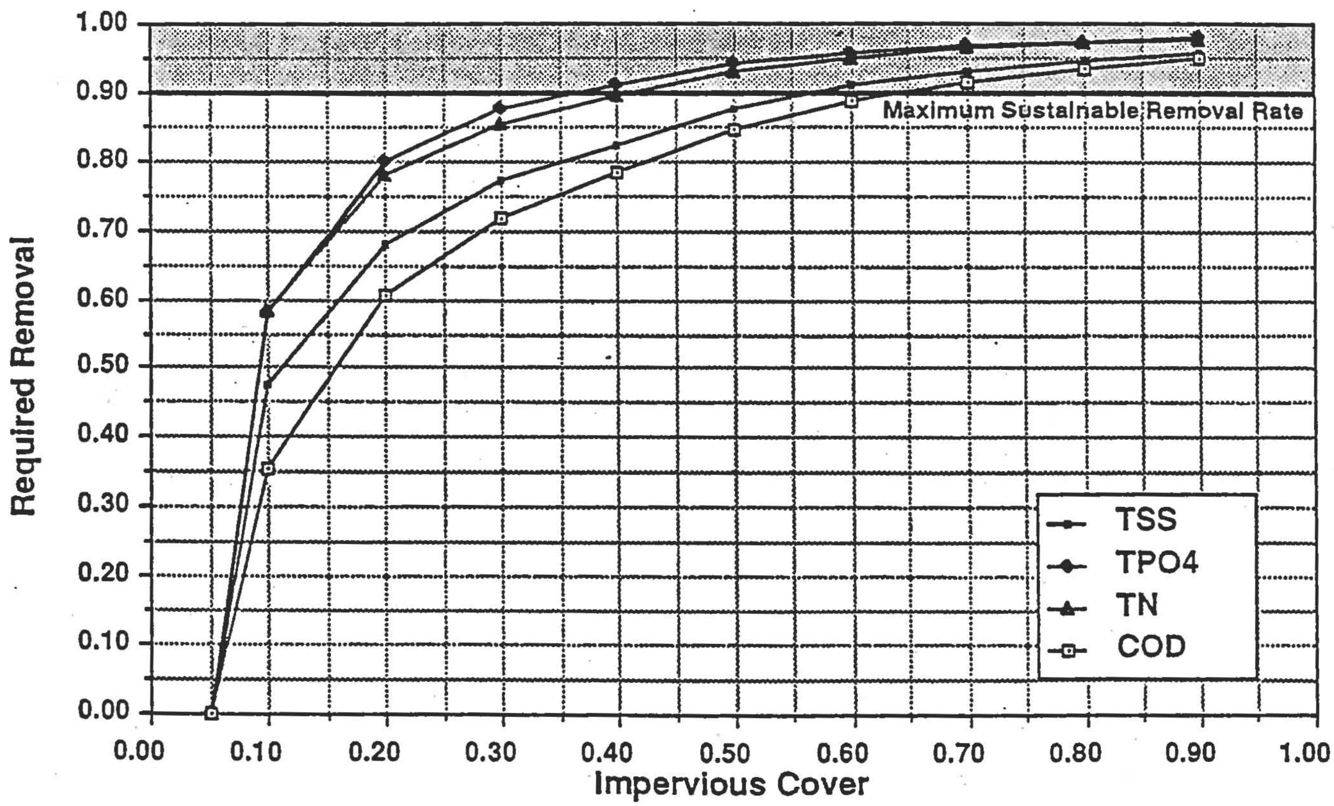


Figure 11. Removal Rates to Achieve Nondegradation for Commercial Land Use over the Recharge Zone

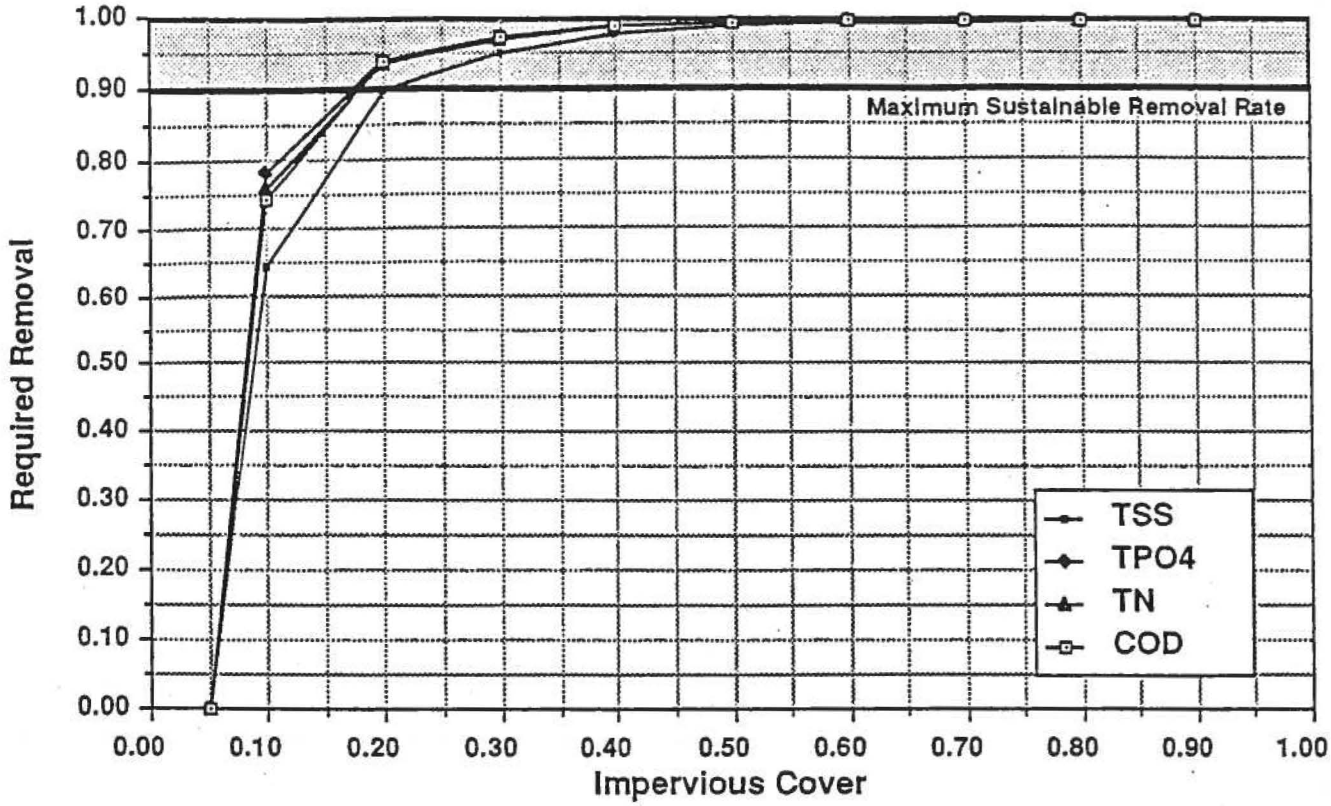
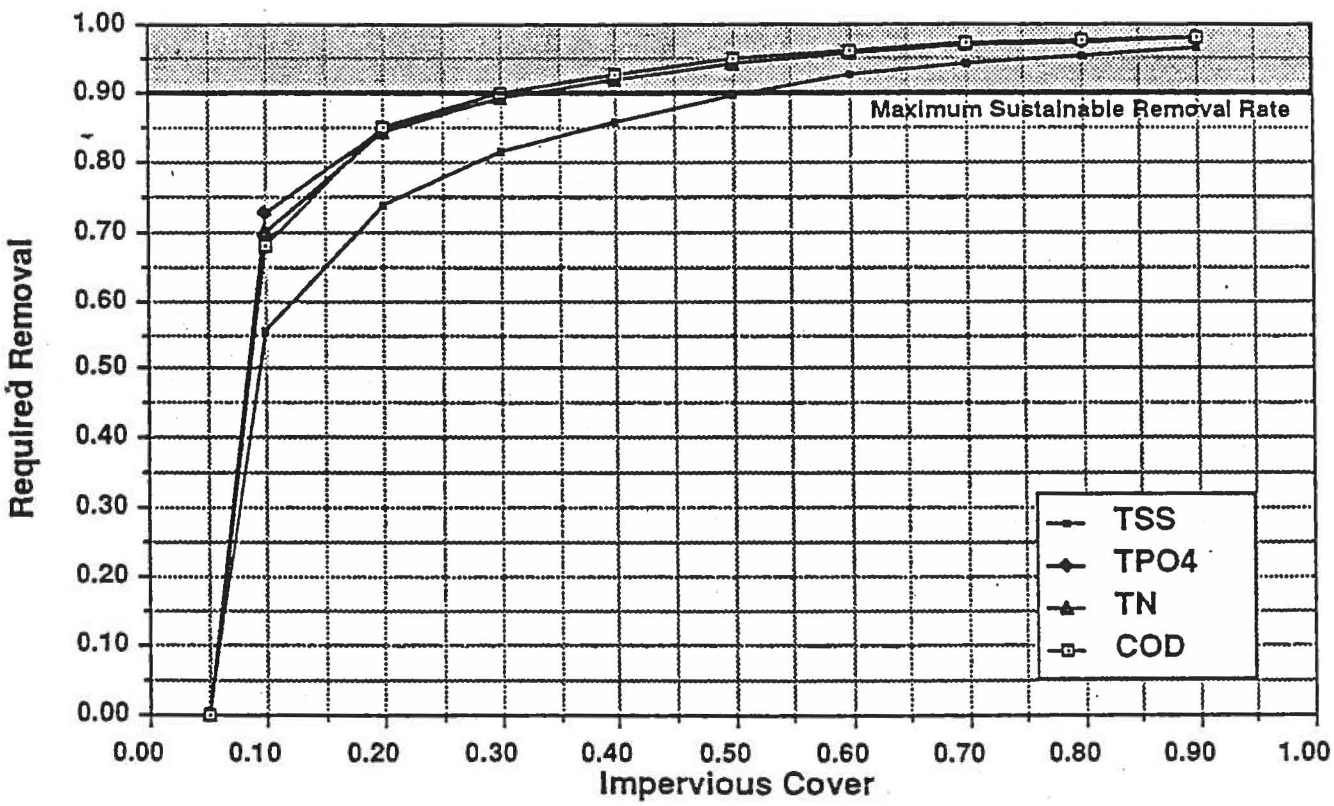


Figure 12. Removal Rates to Achieve Nondegradation for Commercial Land Use for the Non-Recharge Zone



control or streets. This single document could then receive specific review by Environmental and Conservation Services staff to ensure that the nondegradation standard would be achieved.

Modification of the City of Austin's development regulations would provide only part of the solution needed to prevent degradation of water quality in Barton Springs and its contributing watersheds. With the extent of approved projects in the Barton Springs Contributing Zone, it is already too late to keep the stream reaches that are in the City of Austin's jurisdiction at their current high level of quality with regulation of new development alone. Significant pollutant loads are now entering the creeks that recharge the aquifer and new loads will be produced from developments which have been approved, but not yet built and occupied. Large tracts of land in the Barton Springs Contributing Zone within the City of Austin's jurisdiction are exempt under the current configuration of the Land Development Code. Revisions to the Code will be proposed that, if passed, would limit exemptions currently allowed under existing regulations. The remaining new pollutant loads can only be reduced by retrofitting structural stormwater controls, and these most likely would have to be publicly funded. In some cases, the public funding would only be used to contribute to the oversizing of planned private controls. In the balance of cases, land would be required to be purchased in or near existing developments and funds would be needed for design and construction of the controls.

It is expensive to mitigate degradation of water quality to be caused by development not subject to the new nondegradation regulations. The prevention of water quality degradation in Barton Springs and its contributing zone would take significant measures and effort on the part of the City of Austin, its citizens and the development industry. A combination of new watershed regulations, strengthened existing regulations and a publicly funded retrofit program are necessary components of the nondegradation strategy.

SUMMARY AND CONCLUSION

The City of Austin has developed an effective means of nonpoint source pollution control. Preventing this type of pollution is increasingly important to cities wishing to protect the environment related to their water resources. Cities must consider the potential costs of nonpoint source pollution as it relates to drinking water supply, power plant cooling, tourism, recreation and wildlife habitat. As the EPA and state water quality programs increasingly focus on the problems related to nonpoint source pollution, the City of Austin's experience in this type of pollution prevention will prove increasingly beneficial. The development of the Comprehensive Watersheds Ordinance is a valuable tool available for other governmental agencies in their efforts to control nonpoint source pollution. The City of Austin is still wrestling with some of its most serious threats to its water quality, mitigation of impacts from the urban watersheds and protection of its highest quality water in the Barton Springs segment of the Edwards Aquifer and its contributing watersheds.

Figure 11. Comparative Pollutant Removal of Urban BMP Designs
City of Austin Monitoring Data

BMP / Design	SUSPENDED SEDIMENT	TOTAL PHOSPHATE	TOTAL NITROGEN	OXYGEN DEMAND	TRACE METALS	BACTERIA	OVERALL REMOVAL CAPABILITY
SEDIMENTATION/FILTRATION							
DESIGN 1	●	◕	◔	◑	◕	◑	HIGH
DESIGN 2	●	◕	◑	◕	◕	◕	HIGH
FILTRATION							
DESIGN 3	●	○	◔	◔	◑	◔	MODERATE
DESIGN 4	●	○	○	◔	◑	◔	MODERATE
DESIGN 5	◕	◑	◔	◔	◕	○	MODERATE
DESIGN 6	◕	◑	◔	◔	◕	○	MODERATE
WET POND							
DESIGN 7	◑	◔	◔	◔	◑	◔	MODERATE
SEDIMENTATION							
DESIGN 8	○	○	◔	○	○	◑	LOW
GRASSED SWALE							
DESIGN 9	◑	○	◔	◔	○	○	LOW

KEY:
- ○ 0 TO 20% REMOVAL
- ◔ 20 TO 40% REMOVAL
- ◑ 40 TO 60% REMOVAL
- ◕ 60 TO 80% REMOVAL
- ● 80 TO 100% REMOVAL

DESIGN 1: Off-line sedimentation/filtration treating storms with < or = 1/2" of runoff
DESIGN 2: On-line sedimentation/filtration/irrigation treating all runoff
DESIGN 3: On-line sand/sod filtration treating storms with < or = 1/2" of runoff
DESIGN 4: On-line sand/sod filtration treating all runoff
DESIGN 5: On-line sand filtration treating storms with < or = 1/2" of runoff
DESIGN 6: On-line sand filtration treating all runoff
DESIGN 7: On-line minimal detention wet pond treating all runoff
DESIGN 8: Off-line sedimentation treating storms with < or = 1/2 of runoff
DESIGN 9: Steep slope swales ending in sedimentation chamber; no check dams